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A POPULAR GUIDE TO THE GEOLOGY OF THE LONG LAKE PARK HIKE TRAIL

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INTRODUCTION

As shown on the geological map that accompanies this brochure, the Long Lake Park trail describes a four-kilometer loop that can be completed by a brisk walker in about one hour. However, to appreciate the geological features you should allow at least three hours to complete the circuit. The trail is marked by red flagging tape, red reflectors and twenty-one consecutively numbered posts positioned near geological highlights.

This brochure is divided into four parts. Part 1 is a glossary of select geological terms that will help you understand the jargon used in subsequent sections. Part 2 is an introduction to the geological map. Part 3 is an illustrated account of the geological evolution of Long Lake Park, and Part 4 is the trail guide.

PART 1: GLOSSARY OF SELECT GEOLOGICAL TERMS

IGNEOUS ROCKS:
Rocks that originate in reservoirs of molten material (magma chambers) deep below the surface of the earth. The molten material (magma) can rise towards the surface along zones of weakness such as faults and fissures. There are two varieties of igneous rock, volcanic and plutonic. Most of the Long Lake Park area is underlain by igneous rocks, and both volcanic and plutonic varieties are represented.

VOLCANIC ROCKS:
Igneous rocks formed by magma that erupts onto the surface of the earth. When on surface, the magma is called lava. Flows of lava form fine-grained rocks because they chill (cool quickly).

PLUTONIC ROCKS:
Igneous rocks formed by magma that does not reach the surface of the earth, but cools slowly at depth and therefore forms rocks that are coarser grained than volcanic rocks. Plutonic rocks would not be visible to an observer on surface at the time of their formation. Weathering by agents such as ice, wind and water causes the surface to be eroded so that eventually, after millions of years, the plutonic rocks become exposed.

METAMORPHIC ROCKS:
ocks that have been altered by heat and/or pressure. Most of the igneous ocks in the Long Lake area are metamorphosed (altered). However, the egree of metamorphism is not so intense that the original nature of the

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rocks is obliterated, as often happens in highly metamorphosed terrains. Most rock names in the next section of this glossary should be prefixed by the term "meta" to denote that the rocks have been altered, but for simplicity this has not been done.

TYPES OF VOLCANIC ROCK

BASALT:

Basalt is a volcanic rock formed by lava of a specific chemical composition (it is rich in magnesium and iron). Most of the rocks in the Long Lake Park area are basalt (or andesite, a related rock type). Metamorphism has caused these rocks to become dark greenish-grey in colour, and thus they are commonly referred to as greenstones.

TUFF:

Tuff is a volcanic rock that is generally lighter in colour than basalt or andesite because it contains more silica. Lavas rich in silica are too viscous (not fluid enough) to flow onto the surface. Instead, such lava is forcibly ejected from the volcanic vent and falls to the surface through air or water to form layered rock units called tuff.

TYPES OF PLUTONIC ROCK

GABBRO:

Gabbro is a dark greenish-grey plutonic rock chemically similar to basalt, but generally coarser grained because it cooled slowly below the surface and crystallized completely.

DIABASE:

Diabase is gabbro that has a particular texture. At Long Lake, diabase can be differentiated from other gabbros by colour (it weathers brown).

GRANODIORITE:

Granodiorite is a plutonic rock formed from magma richer in silica than the magma that forms gabbro or diabase. At Long Lake, granodiorite is buff to pink and most examples are coarse grained.

TYPES OF PLUTONIC BODIES

BATHOLITH:

A large mass of plutonic rock having a surface exposure of more than 100 square kilometers. A granodiorite batholith is present in the Long Lake Park area.

DIKE:

A tabular-shaped body of plutonic rock that cuts across (is discordant to) the depositional planes of the surrounding rocks. Granodiorite, gabbro and diabase dikes are present in the Long Lake area. They are usually less than several meters wide, but extend for much greater distances in the other two dimensions. Some of the gabbro dikes may represent passageways through which magma flowed to reach the surface and form the volcanic flows.

SILL:

A tabular-shaped body of plutonic rock that is parallel to the depositional planes of the surrounding rocks. Dikes and sills differ only in their attitude with respect to the rocks that they intrude.

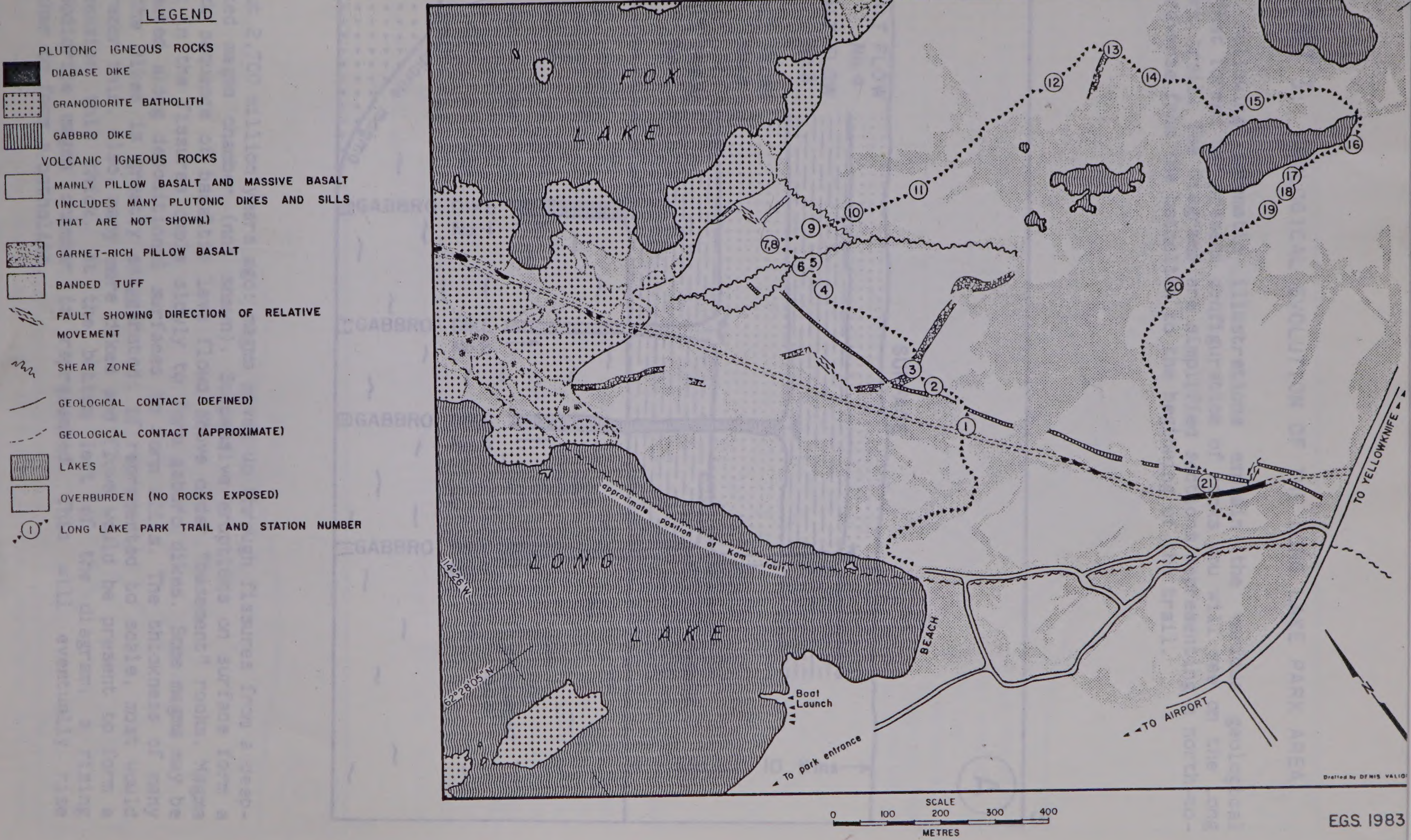
PART 2: THE GEOLOGICAL MAP

Long Lake Park is underlain by both volcanic and plutonic igneous rocks. The volcanic rocks are about 2,700 million years old and were formed during a time geologists call the Precambrian. The plutonic rocks are also Precambrian, but are younger than the volcanics. On the geological map you will see a line (or geological contact) to the south of Fox Lake separating a white region from a region patterned by crosses.

The white region is underlain by basalt, a volcanic rock. The crossed area is part of a granodiorite batholith. If you straddle this contact, one foot will be on pink, coarse-grained granodiorite and the other foot will be on dark-greenish-grey, fine-grained volcanic rock some 100 million years older than the batholith. The volcanic rocks have been named the "Kam Formation"; the batholith the "Western Granodiorite". The gold deposits of the Con and Giant Mines are in volcanics of the Kam Formation, which extends to the southeast and northwest of Long Lake Park. The Kam Formation was metamorphosed during intrusion of the Western Granodiorite.

The contact between the Kam Formation and the Western Granodiorite is the most conspicuous geological feature of the Long Lake area, but other details are shown on the map. For instance, various symbols representing faults, shear zones, tuff beds, garnetiferous beds, gabbro dikes, diabase dikes, lakes and areas covered with sand, gravel, clay and peat (overburden) are shown. The symbols are explained in the map legend and the various geological units are more fully described in Part 4. It is important to understand that the geological map is simplified in order to make it more understandable to the non-geologist (a detailed geological map of Long Lake Park, presently being prepared by the Geology Division of Indian and Northern Affairs Canada, should be available in 1984). On the simplified map, only the largest and most easily recognizable gabbro dike is shown. In fact, there are many gabbro dikes cutting the Kam Formation. Similarly, only the most conspicuous tuff bed and diabase dike and only the most prominent faults and shear zones are shown. This simplification adds an element of challenge to the person using this guide. Once a geological unit has been introduced, the participant is challenged to recognize similar (but less conspicuous) units that are not shown on the map.

A LAYPERSON'S GEOLOGICAL GUIDE TO THE LONG LAKE PARK AREA


LEGEND
PLUTONIC IGNEOUS ROCKS
DIABASE DIKE
GRANODIORITE BATHOLITH
GABBRO DIKE
VOLCANIC IGNEOUS ROCKS
MAINLY PILLOW BASALT AND MASSIVE BASALT (INCLUDES MANY PLUTONIC DIKES AND SILLS THAT ARE NOT SHOWN.)
GARNET-RICH PILLOW BASALT
BANDED TUFF
FAULT SHOWING DIRECTION OF RELATIVE MOVEMENT
SHEAR ZONE
GEOLOGICAL CONTACT (DEFINED)
GEOLOGICAL CONTACT (APPROXIMATE)
LAKES
OVERBURDEN (NO ROCKS EXPOSED)
LONG LAKE PARK TRAIL AND STATION NUMBER
FOX LAKE
LONG LAKE
approximate position of Kam fault
114°26'W
62°28'05"N
BEACH
Boat Launch
To park entrance
TO AIRPORT
TO YELLOWKNIFE
N
1
2
3
4
5
6
7,8
9
10
11
12
13
14
15
16
17
18
19
20
21
SCALE
0
100
200
300
400
METRES
Drafted by DENIS VALIO

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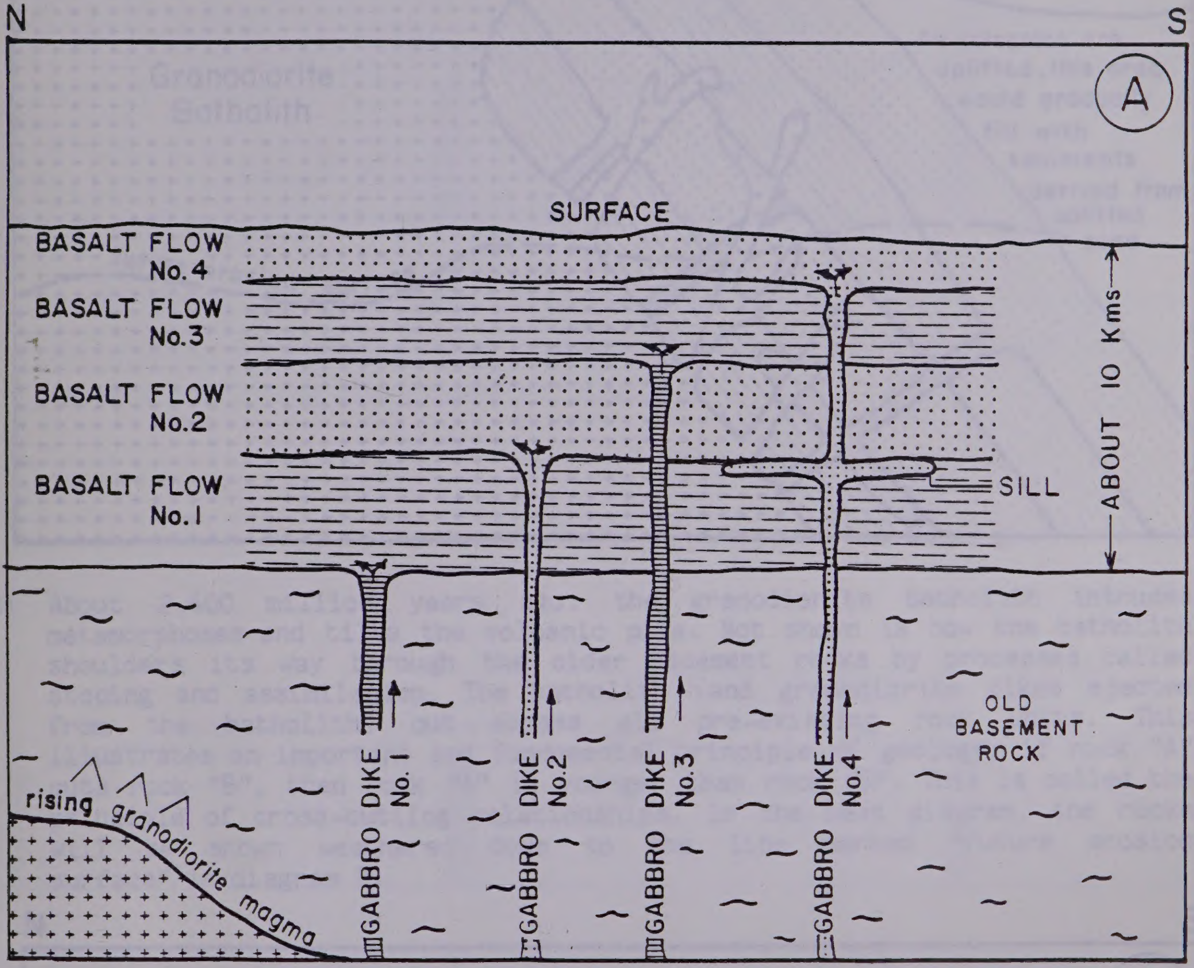
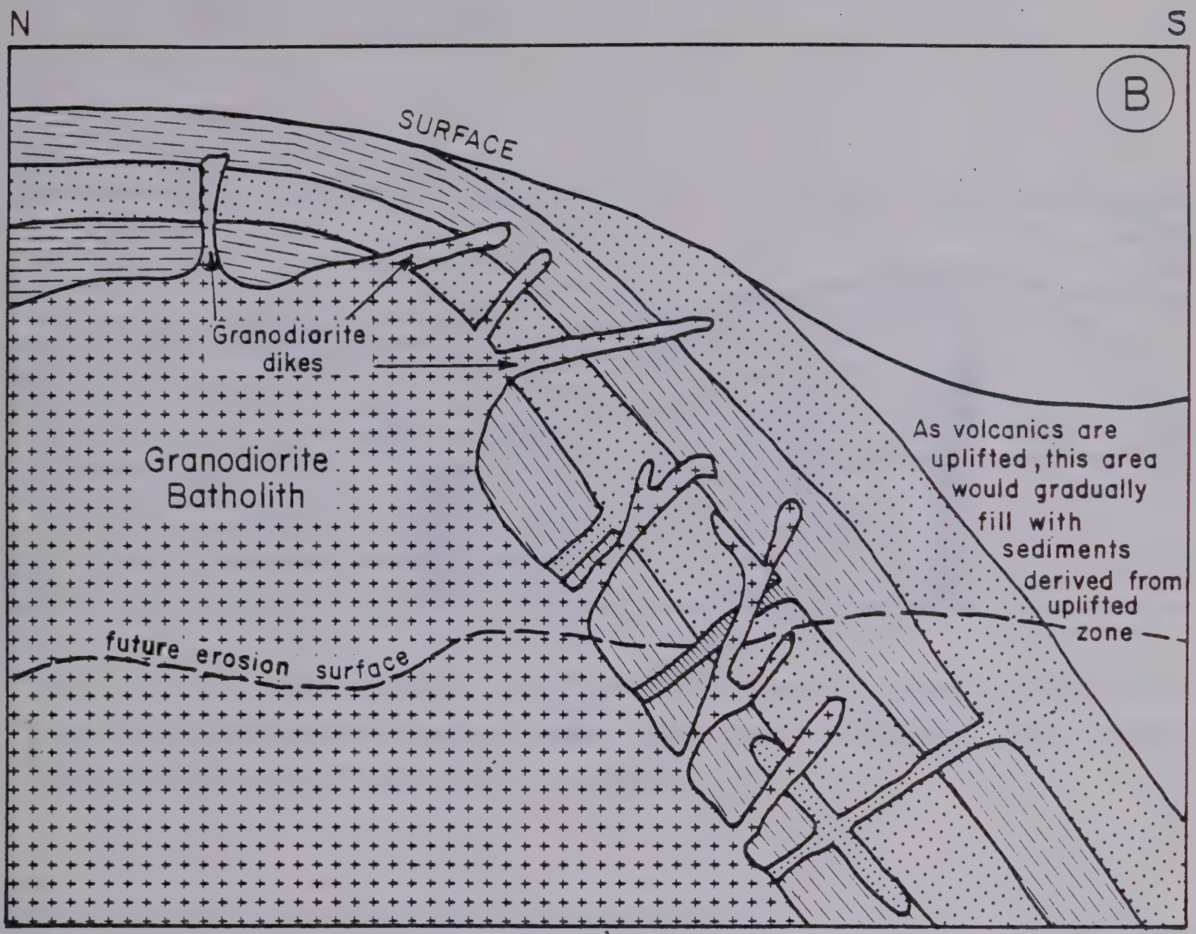
PART 3: GEOLOGICAL EVOLUTION OF THE LONG LAKE PARK AREA

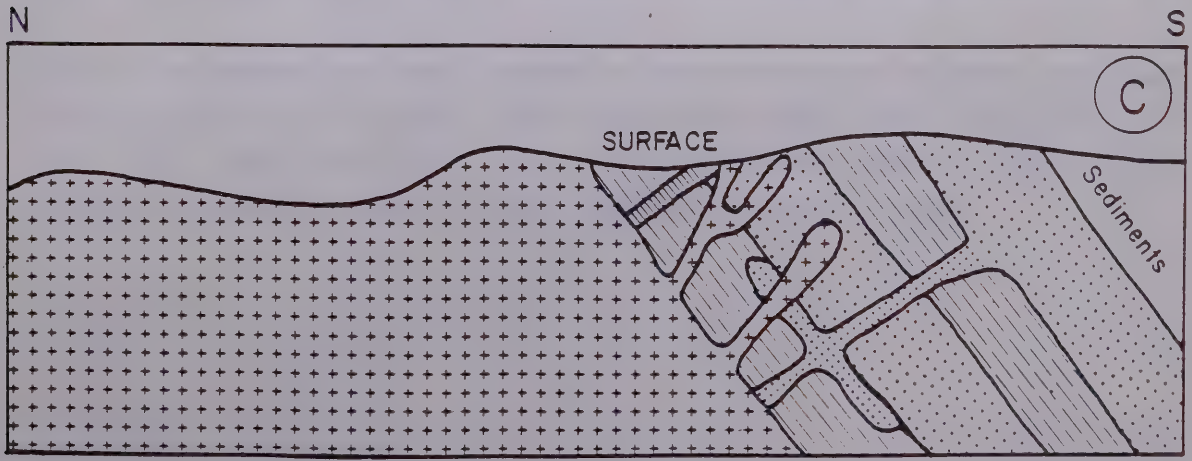
The following schematic illustrations explain the various geological events that formed the present configuration of rocks you will see on the Long Lake Park trail. The diagrams are simplified sections representing a north-to-south traverse from the batholith to the beginning of the trail.



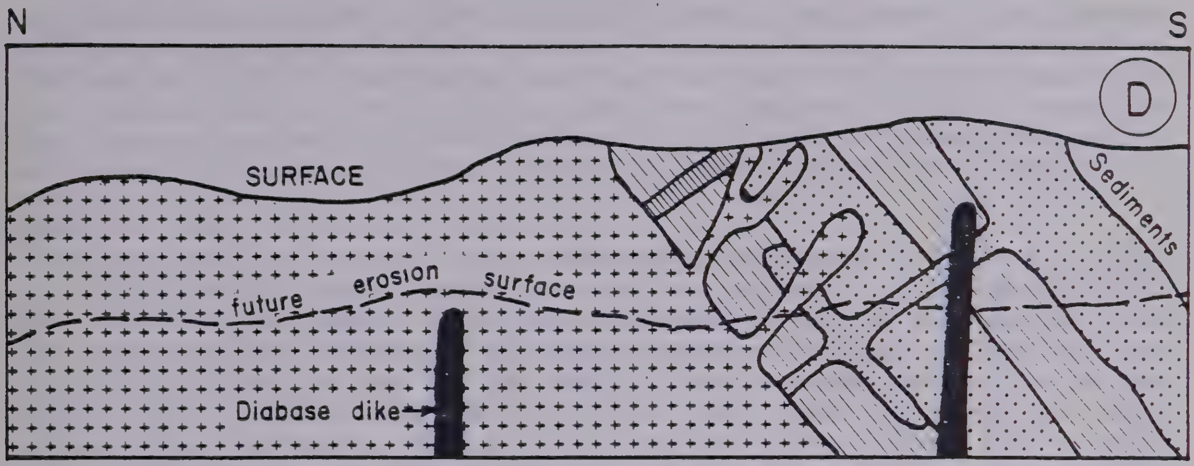
A) About 2,700 million years ago: magma moves up through fissures from a deep-seated magma chamber (not shown). Successive eruptions on surface form a thick sequence of basaltic lava flows above older "basement" rocks. Magma left in the fissures cools slowly to form gabbro dikes. Some magma may be injected along depositional surfaces to form sills. The thickness of many of the dikes is greatly exaggerated; if represented to scale, most would be razor thin. Also, many more dikes and flows would be present to form a succession this thick. At the bottom left of the diagram, a rising granodiorite magma chamber is represented. This will eventually rise further to form a batholith.


N
S
B
SURFACE
Granodiorite dikes
Granodiorite Batholith
future erosion surface
As volcanics are uplifted, this area would gradually fill with sediments derived from uplifted zone

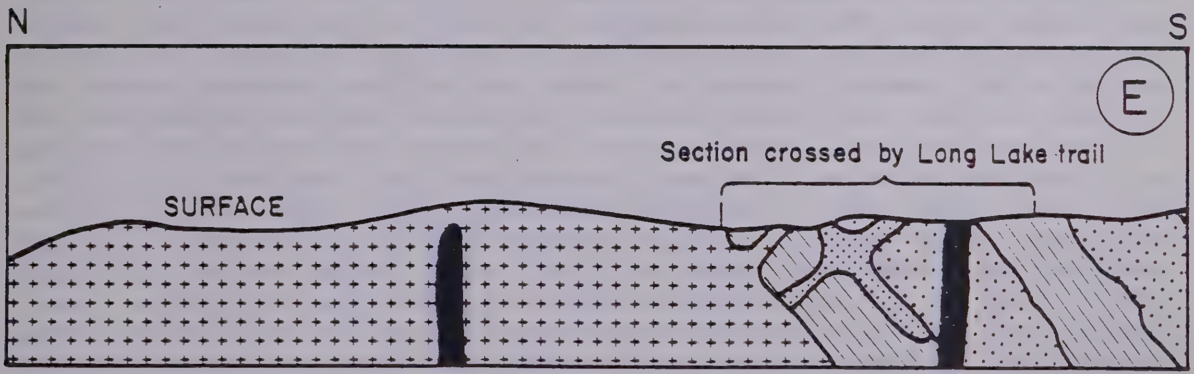
B) About 2,600 million years ago: the granodiorite batholith intrudes metamorphoses and tilts the volcanic pile. Not shown is how the batholith shoulders its way through the older basement rocks by processes called stoping and assimilation. The batholith (and granodiorite dikes ejected from the batholith) cut across all pre-existing rock units. This illustrates an important and fundamental principle of geology; if rock "A" cuts rock "B", then rock "A" is younger than rock "B". This is called the principle of cross-cutting relationships. In the next diagram, the rocks will be shown weathered down to the line marked "future erosion surface" in diagram B.



C) About 2,500 million years ago: The surface has been weathered and eroded so that the batholith and various dikes are now exposed.



D) About 2,500 million years ago: There is another episode of magmatic activity. A deep-seated magma chamber (not shown) is tapped, and diabase dikes are intruded along zones of weakness.



E) TODAY: The surface has been lowered by weathering and erosion (including recent glaciation) to expose the diabase and other rocks along the Long Lake Park trail. Note that for simplicity the numerous episodes of faulting and shearing have not been depicted on these diagrams.

PART 4: LONG LAKE PARK TRAIL GEOLOGICAL GUIDE

START:

New park roads, built after the geological map was printed, have obliterated the beginning of the trail, which now starts just before STATION 1 and not by the lakeshore as shown on the map. Signs posted in the park will direct you to the new start of the trail. Before you begin your hike, separate the geological map from the rest of these pages so that you can continually refer to it as you walk. Notice the north arrow on the map and be aware of the direction in which you are travelling.

STATION 1:

A diabase dike is visible about 8 meters before the post marking station 1. The dike has a brown surface and so can be easily distinguished from the greenish grey basalt flows you are standing on. Go back to the dike and study the contact between the basalt and the diabase. Notice that the diabase is finer grained at the contact than towards the center of the dike. This is because the margin of the dike cools (or "chills") more quickly than the centre. Notice on your map that the diabase dike is only exposed in a few places within a long, narrow valley. This is because the diabase dike is less resistant than the surrounding rocks; it is recessive weathering and therefore forms a valley. Notice also that the diabase dike cuts the volcanics and the granodiorite batholith, and so must be younger than both of these rocks.

STATION 1 TO STATION 2:

Between station 1 and station 2 you will see an unnumbered post with a red reflector on it. To the left (southwest) of this post, look for a peculiar-looking rock that consists of millimeter-to centimeter-size white spots on a dark grey background. This is a gabbro dike. The white spots are crystals of feldspar; they are called phenocrysts and are restricted to the center (hottest part) of the dike. The contact between the dike and the surrounding volcanic rocks might be difficult for you to identify because the colour and texture of the two rocks are similar near the contact. If you can find the contact, you will be able once again to verify the chilling effect mentioned previously; the gabbro near the centre of the dike will be coarser grained than the gabbro near the margin. On the map you will see that this particular gabbro dike has been traced across the Long Lake park area. In some areas, it has been offset along faults. Distinctive and continuous rock units such as this gabbro dike are useful to geologists because they serve as markers that can be used to solve structural problems (such as the direction and magnitude of offset along faults). This area displays other important features. Notice the pattern of curves (that outline crudely bun-shaped forms) in the volcanic rocks. These forms are called pillows, and the volcanic rock is called a pillow basalt. Pillow basalt forms when basalt is extruded under water or ice. In some of the pillows you may notice cavities ranging from a few millimeters to several centimeters in length. (These are most evident on the east side of the trail about 10 metres before the post). These are called vesicles and were formed by gases escaping from the pillow. Many of the volcanic flows in the Long Lake area are pillow basalts, although they are not always as clearly defined as these. Other flows are massive (without structure).

STATION 2:

The arrows point to the margins or selvages of a pillow. The selvages were initially glassy because the pillows chilled, much like the dike discussed earlier. Subsequent metamorphism has caused the selvages to recrystallize.

STATION 3:

The small, brownish, raised grains that you see in this pillowed basalt (the pillows are not very obvious) are garnets. As you can see on your map, this garnetiferous unit has been traced discontinuously across most of Long Lake Park. It is another important marker unit. The garnets stand out in relief because they are more resistant to weathering. This illustrates a process called differential weathering. The garnets probably formed during metamorphism after the basalt was deposited. Such secondary minerals are called porphyroblasts.

STATION 4:

Here you see a quartz vein cutting the volcanic rocks. Like other quartz veins in the Yellowknife area, there is a good chance that this one contains traces of gold. However, the vein would have to be much wider to be profitably mined. Veins such as this in the Yellowknife area probably formed during metamorphism.

STATION 5:

This is a trench dug in a valley. Look carefully at the rock at the south end of the trench. Notice the frayed, planar fabric? This is due to a process called shearing, a form of metamorphism where movement is a major component of the process. This weakens the rocks and makes them easier to weather, and so the shear zone forms a valley. The gold deposits of the Con Mine and Giant Mine are in shear zones similar to this. Samples collected from this shear zone contained ore-grade concentrations of gold. It is possible that you will find visible gold if you hunt for it (most gold in this area is too fine to be seen except with a microscope).

STATION 6:

Here is another trench in the same shear zone. Notice the red colour of many of the boulders in the trench. Zones of red colouration such as this are called gossans. They form by the oxidation of iron sulphides. Gossans indicate to prospectors and geologists that there may be a deposit of metals nearby.

STATION 6 to STATION 7:

Stop for a moment after you've taken ten or so paces out of the valley and are climbing up the rocks towards station 7. You are standing on volcanics again, but they are slightly red or gossanous. To your right (east), you will see massive, coarse-grained, dark greenish grey rock that looks very different from what you are standing on. This is a large, irregular gabbro body, probably a sill. The intrusion of this sill was probably responsible for forming the gossan you are standing on.

STATION 7 (and 8):

The tripod marks the highest ground for some distance. Notice the round metal plaque imbedded in the rock. This marks a geodetic survey point. Surveyors have tied-in this point to other geodetic survey points to provide a network of ground control for topographic maps. Look to the north across Fox Lake and you will see light-coloured rocks of the granodiorite batholith. If you want to see the granodiorite-volcanic contact, leave the trail and walk north for about the length of a football field (you'll be able to see the tripod at all times, so getting back to the trail will be no problem). Look at your map. Just before reaching the contact, you will cross a banded tuff unit (it's hard to miss; it's about 2 metres wide, lighter-coloured than the volcanics, darker coloured than the granodiorite and has a conspicuously banded appearance). Walk past the tuff unit to see the granodiorite-volcanic contact. Then return to the tuff unit and follow it for a short distance towards the east. You will see that it ends against a quartz vein in a small valley. This quartz vein marks a fault. Look at the map again; you will see that the tuff bed has been offset about 50 metres southwards along the fault. You may wish to satisfy yourself on this point by finding the tuff bed on the other side of the fault, but before you do this look at the quartz vein again. Notice that it does not extend into the granodiorite. This means that the fault occurred prior to the intrusion of the batholith. Return to the tripod to resume your hike.

STATION 8 to STATION 9:

Once you leave the hill with the tripod on it, you will be walking mainly on gabbro that forms an irregular intrusion or sill. Notice the coarse grain size. You will also pass several granodiorite dikes.

STATION 9:

This is a granodiorite dike. You have passed many of these on your walk. Dikes such as this were expelled from the granodiorite batholith.

STATION 10:

Here is another granodiorite dike, unusual because of its horizontal orientation.

STATION 11:

Notice the forty-centimeter-wide, dark-coloured gabbro dike cutting lighter-coloured volcanics. The chilling effect is not pronounced in dikes that are this narrow because the whole dike is chilled.

STATION 12:

Notice that the narrow granodiorite dike ends abruptly at a crack in the rock. This crack is a fault. Walk south along the crack for a few paces and you will see the same dike. It has been offset by about six metres. Some faults in the Yellowknife area displace structures by as much as five kilometers.

STATION 13:

Notice the rusty weathering of this rock and the brownish-red spots. The spots are probably garnets, and this rock may be the eastward extension of the garnetiferous unit you saw at Station 3.

STATION 14:

About 10,000 years ago most of Canada was covered by glaciers. When they retreated, much of western N.W.T. was covered by a huge lake called Glacial Lake McConnel. Notice the rounded boulders at this station. These were transported here by glaciers and are called erratic boulders. Originally, these boulders were imbedded in a mixture of ground-up rock and sand called till. The fines in the till were washed into low-lying areas, leaving the erratic boulders behind. Some of the erratic boulders in the Long Lake area were transported from as far away as the East Arm of Great Slave Lake, about 150 km towards the east.

STATION 15:

This is an old exploration camp, probably dating from the 1940's. If you wander around this area, you can find granodiorite dikes containing angular fragments of volcanic material. These dikes, introduced explosively into the Kam Formation, ripped up pieces of volcanics and transported them upwards.

STATION 16:

Look for a 20-centimeter-wide, smooth scour on the rock. This was caused by glaciers scraping and polishing the rock. The direction of the scour (250°) indicates the direction of movement of the glacier. Throughout the Long Lake area, you may have noticed long, millimeter-wide, parallel grooves or indentations in the rocks. These were formed by pebbles being dragged across the rock along the base of the glacier. These also indicate a direction of glacial advance from the northeast.

STATION 17:

Notice the cracks in the rock. These are caused by ice wedging, a very efficient weathering process. Water expands when it freezes, and it is the pressure from this expansion that wedges or opens the cracks in the rocks.

STATION 18:

Here are some well-formed, bun-shaped, elongated basalt pillows. Notice how deeply indented the margins (selvages) of the pillows are. This is another example of differential weathering. The material in the selvages is softer than the material in the pillows and therefore erodes more easily.

STATION 19:

Here prospectors have blasted a thin vein of quartz, undoubtedly searching for gold.

STATION 20:

This large, swampy area is known as a muskeg. It is underlain by silt and clay washed from the till originally deposited on the rock outcrops.

STATION 21:

You have just passed the same gabbro dike you saw between stations 1 and 2, although because of ground conditions here it is not easy to spot. This is the end of the trail. You will notice large pillows in this area as well as a prominent glacial scour. The skyline of Yellowknife is visible to the southeast. Walk south to the road and you will soon cross the same diabase dike that you saw at station 1.

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